Light Dedicated Hybrid Transmission for 2-Wheelers

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Agenda

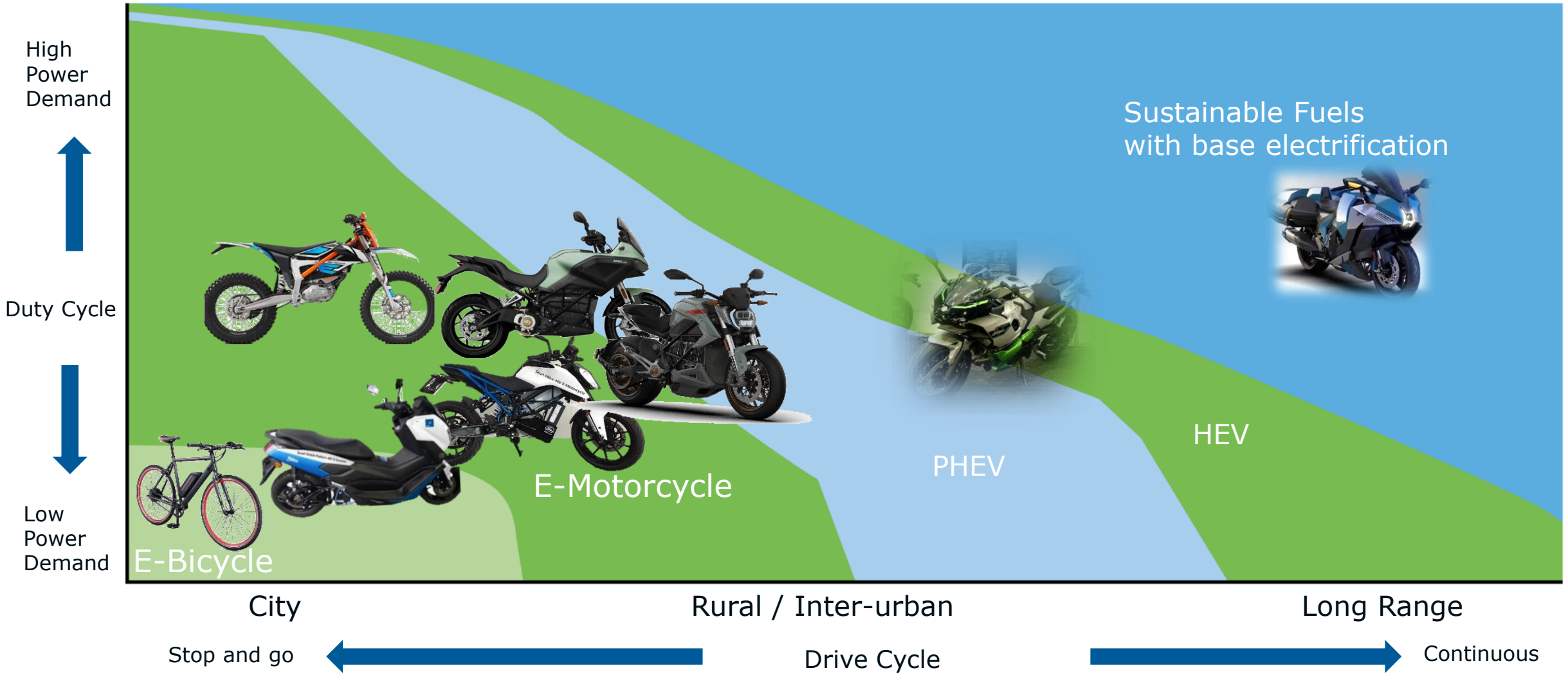


Motivation for Hybridization

2-Wheeler electrification routes

Dedicated Hybrid Transmission for 2-Wheeler

Mobility is getting Electrified



Agenda



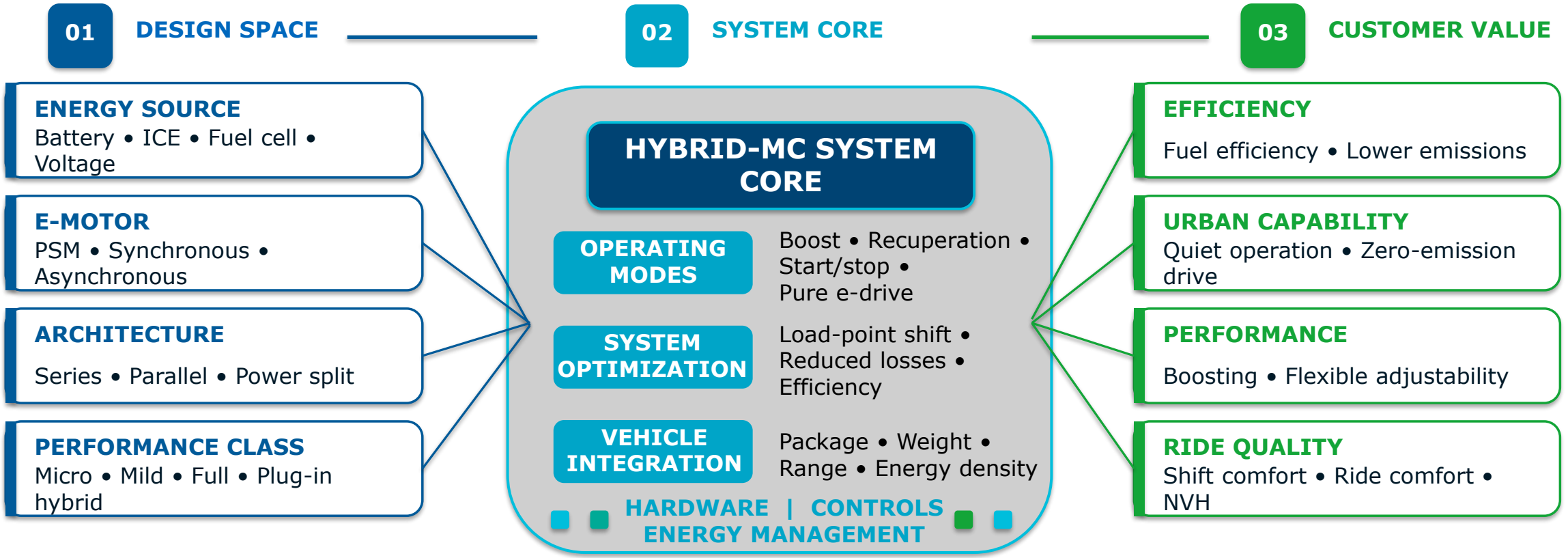
Motivation for Hybridization

2-Wheeler electrification routes

Dedicated Hybrid Concepts with DHT

Hybrid Motorcycle Technology System Map

Future-ready architecture selection based on application priorities



DECISION INPUTS

APPLICATION
Vehicle class • Region • Usage

PROGRAM
Cost • Timing • Maturity

ASSURANCE
Safety • Durability • Validation

IMPORTANT!
Quantify priorities before architecture selection

Agenda



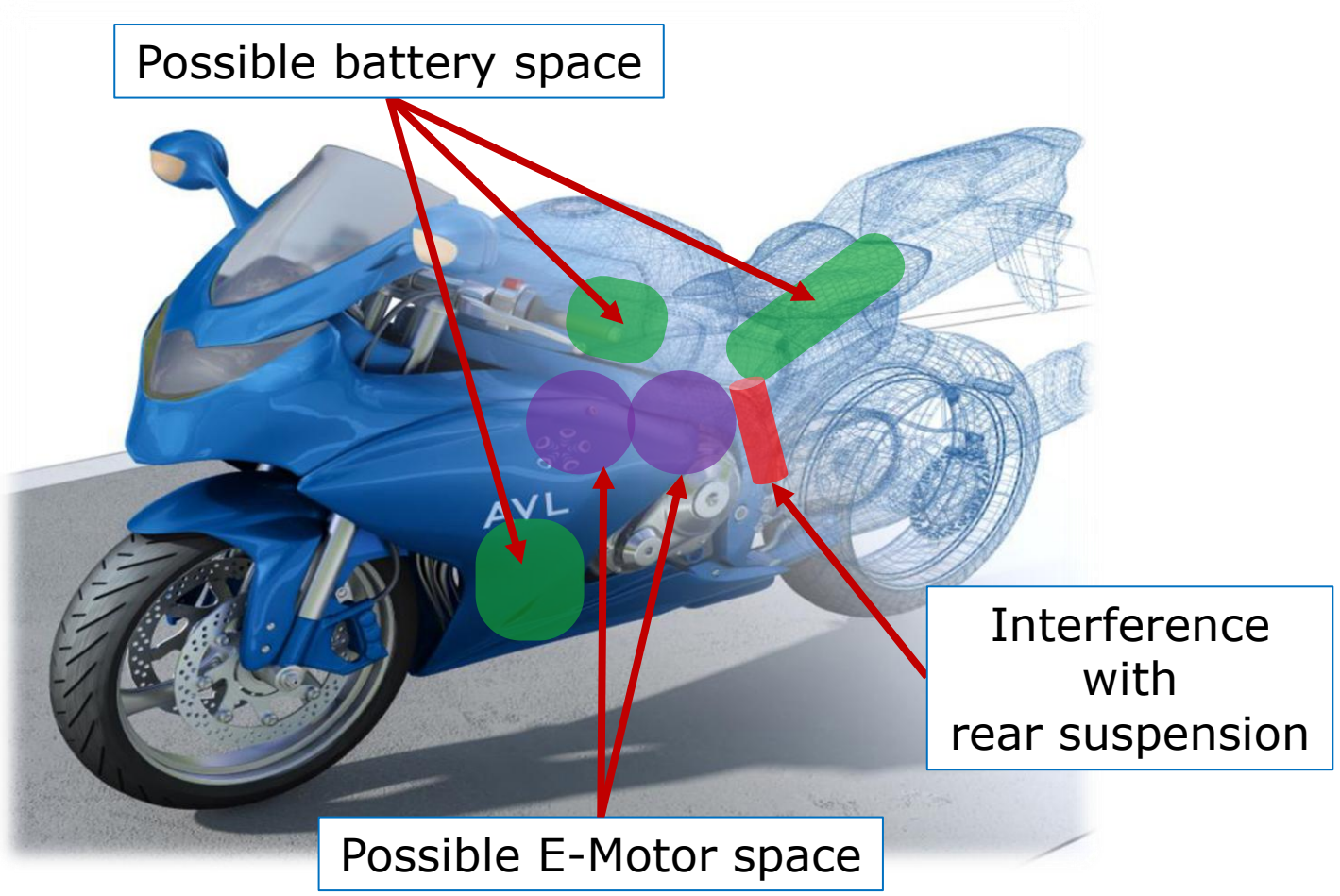
Motivation for Hybridization

2-Wheeler electrification routes

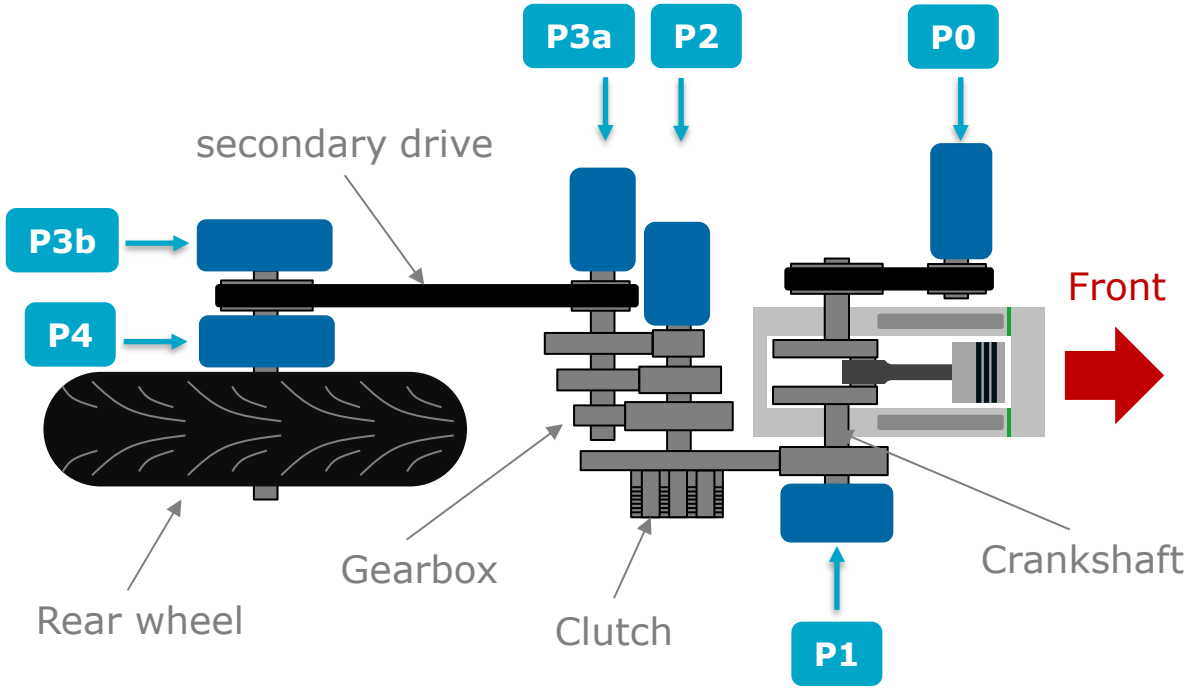
Dedicated Hybrid Transmission for 2-Wheeler

Performance Hybrid Motorcycle
Hybrid Features & Functions

Feature and function definition					
		Must	Should	Could	Won't
Hybrid general	Advanced stop start			X	
	Charging at standstill		X		
	Charging at driving	X			
	Recuperation		X		
	Boost	X			
	Sailing			X	
	Coasting			X	
	eCreep / reverse gear		X		
	Electric drive	X			
	Engine shutdown assist				X
	Engine stall protection				X
	eAWD				X
Performance Features	Handling	X			
	Torque fill		X		
	eClutch necessary			X	
	System complexity		X		
	Function complexity		X		



Hybrid Architecture Overview



INTEGRATION POSITIONS

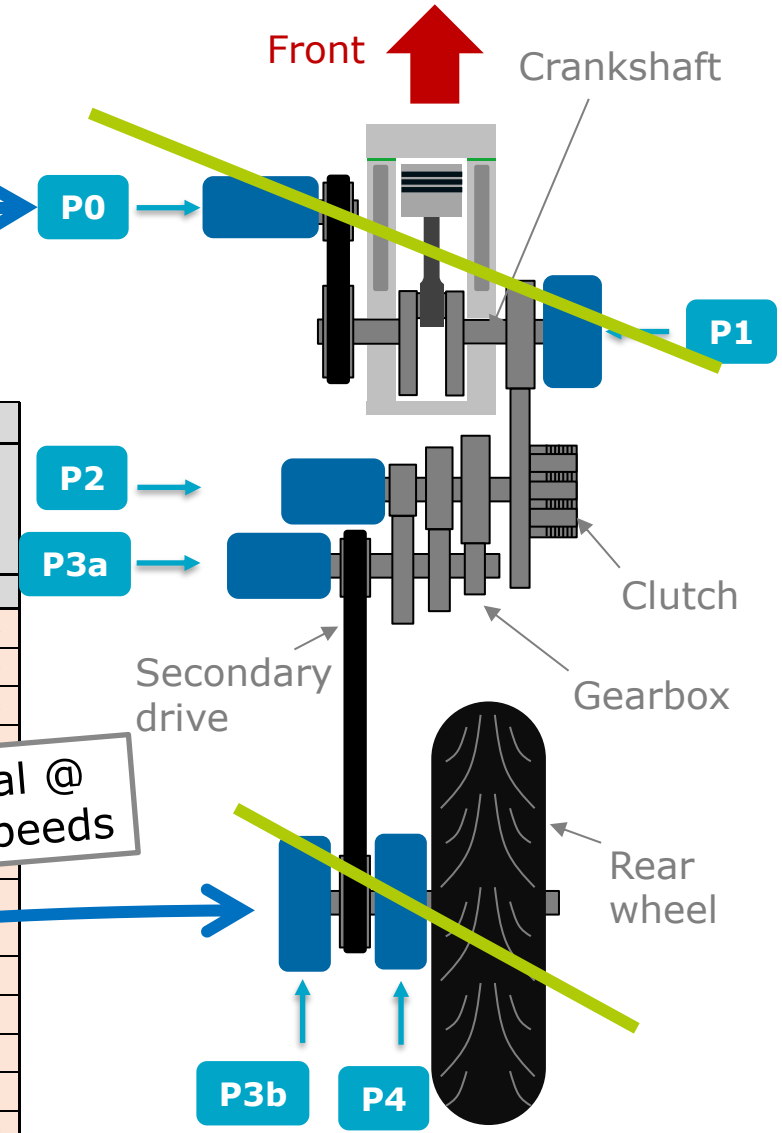
- **P0** Belt-starter-generator (ISG)
- **P1** Motor-generator directly connected to the engine crankshaft
- **P2** Motor-generator after engine disconnect and before transmission input clutch
- **P3a** Motor-generator on transmission output
- **P3b** Motor-generator on drive axle, with mechanical prop shaft
- **P4** Motor-generator on drive axle, without mechanical connection

Performance Hybrid Motorcycle
Hybrid Topology Options - Pre - Rating Matrix

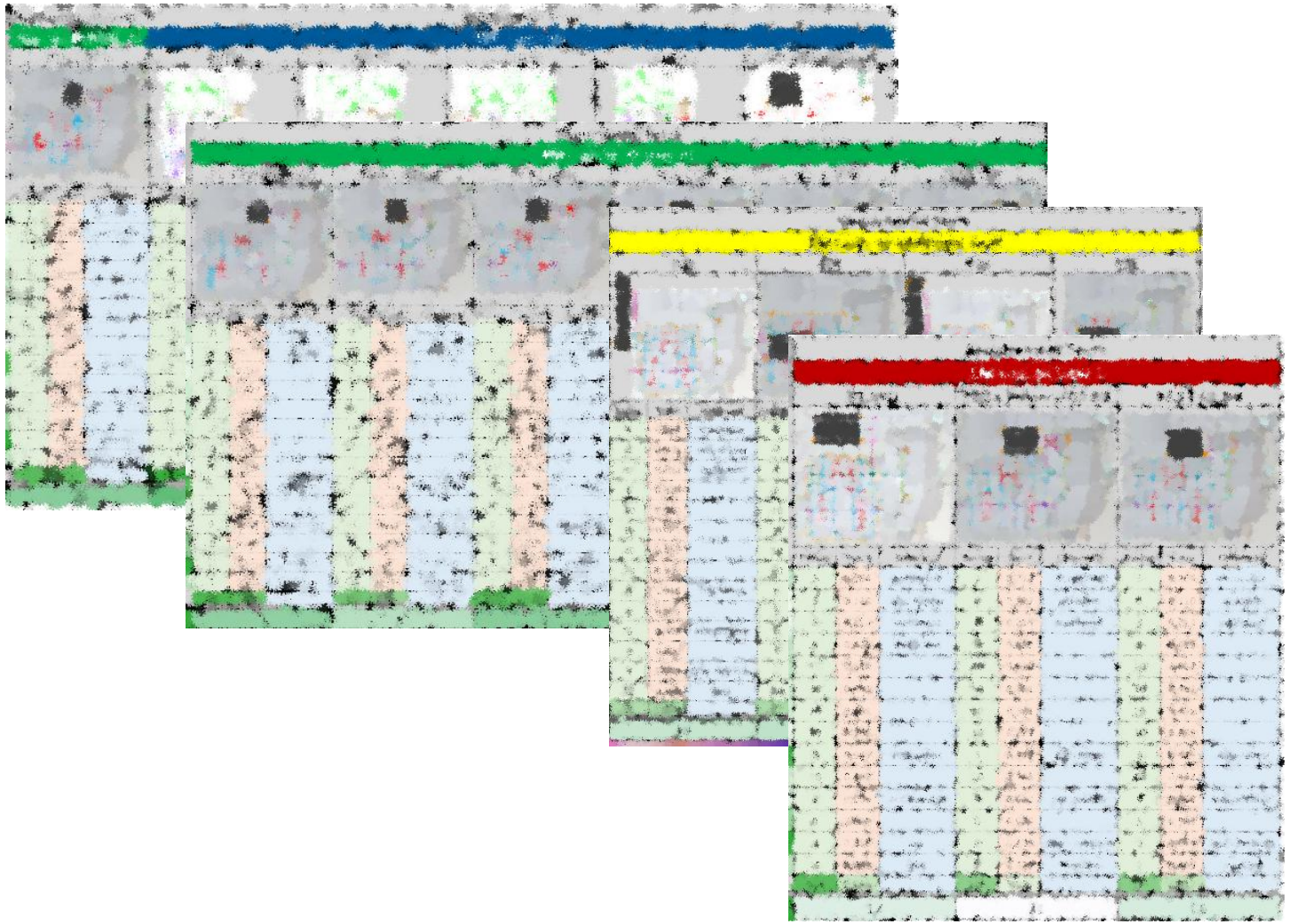
won't fulfil must-criterion

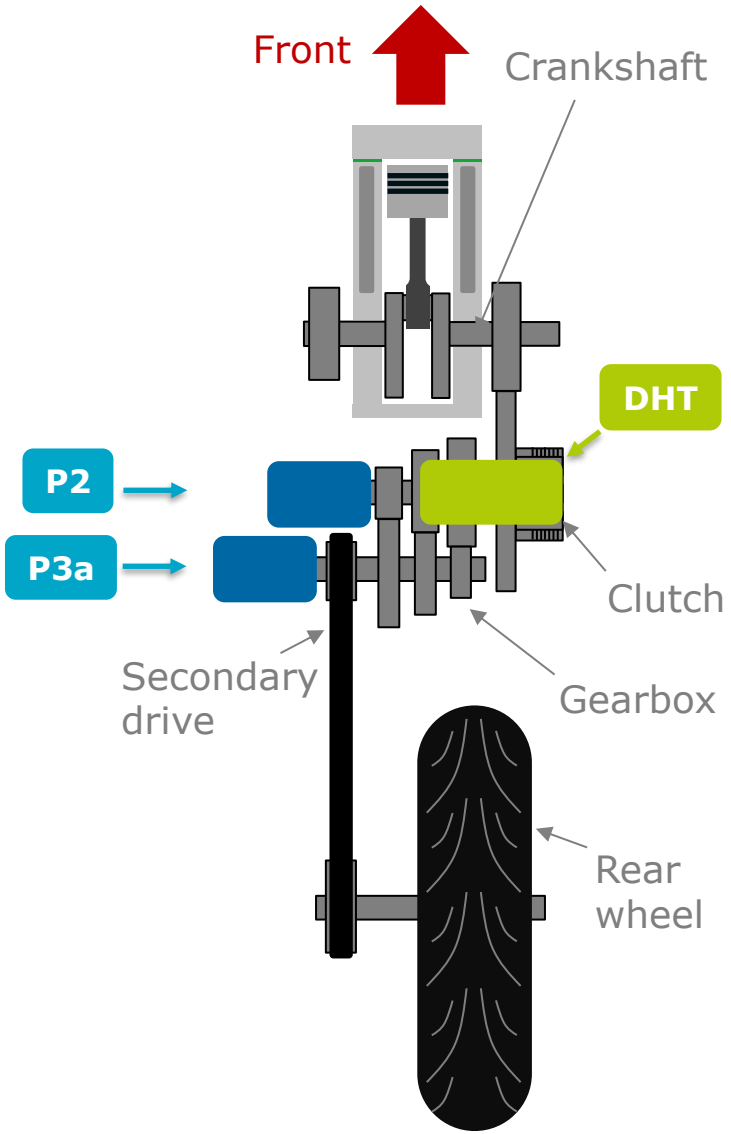
Critical @ high speeds

	Features & Functions	Performance	Emission	eRange	Synergies	Cost	Noise	Weight	Weighting	P0		P1		P2.xx		P3		P4		DHT	
										Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Hybrid general	Advanced stop start								5%	10	0.529	10	0.529	8	0.423	0	0.000	0	0.000	5	0.264
	Charging at standstill								2%	10	0.221	10	0.221	10	0.221	0	0.000	0	0.000	5	0.110
	Charging at driving								3%	10	0.267	10	0.267	10	0.267	8	0.214	7	0.187	8	0.214
	Recuperation								5%	2	0.107	2	0.107	10	0.537	9	0.483	10	0.537	10	
	Boost								6%	8	0.488	10	0.610	10	0.610	10	0.610	10	0.610		
	Sailing								5%	0	0.000	0	0.000	10	0.481	10	0.481	10	0.481		
	Coasting								5%	10	0.481	10	0.481	10	0.481	8	0.385	8	0.385		
	eCreep / reverse gear								3%	2	0.052	2	0.052	10	0.259	10	0.259	10	0.259	10	0.259
	Electric drive								19%	0	0.000	0	0.000	10	1.897	10	1.897	10		10	1.897
Performance Features	Handling								4%	4	0.177	4	0.177	10	0.442	8	0.353	2	0.088	10	0.442
	Torque fill								3%	0	0.000	0	0.000	0	0.000	10	0.344	10	0.344	5	0.172
	eClutch necessary								11%	10	1.086	10	1.086	0	0.000	0	0.000	0	0.000	5	0.543
	System complexity								21%	10	2.146	10	2.146	8	1.716	10	2.146	10	2.146	2	0.429
	Function complexity								7%	10	0.698	10	0.698	5	0.349	8	0.559	8	0.559	2	0.140
	Total	100%	100%	100%	100%	100%	100%	100%	100%	96	6.253	108	6.375	131	7.686	101	7.732	105	7.494	112	6.581



Performance Hybrid Motorcycle
Highly Integrated DHT – Lightweight Electrification





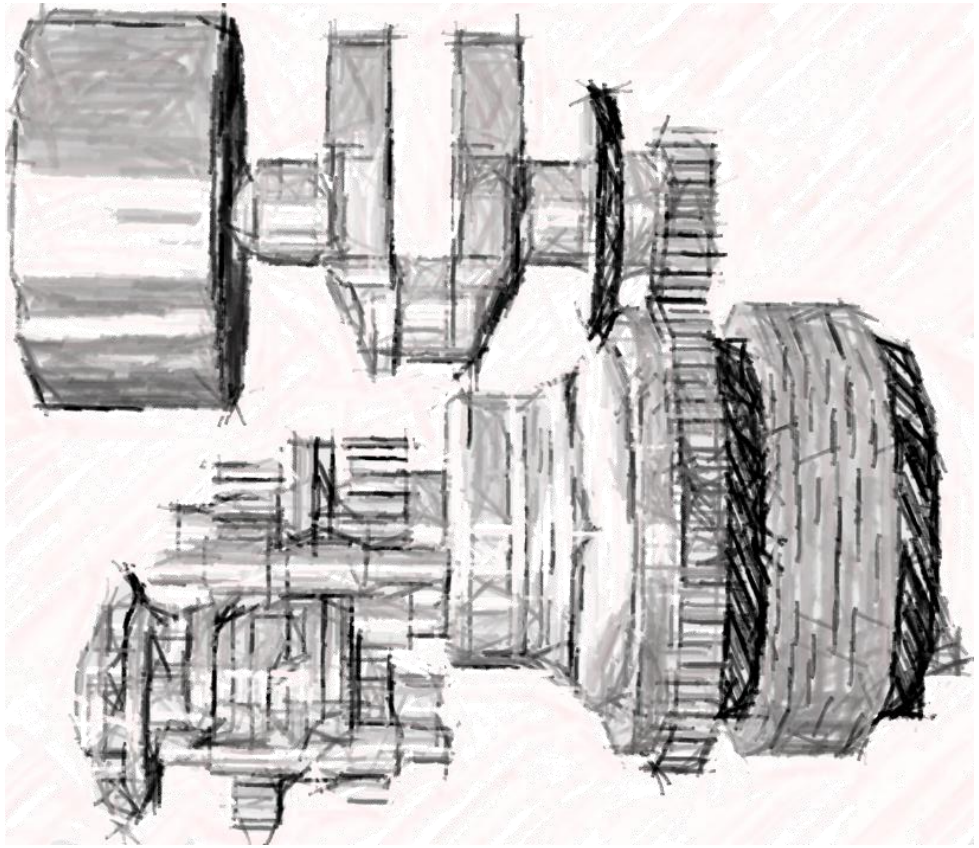
Light DHT Hybrid Powertrain
Highly Integrated DHT – Lightweight Electrification



DHT= dedicated hybrid transmission

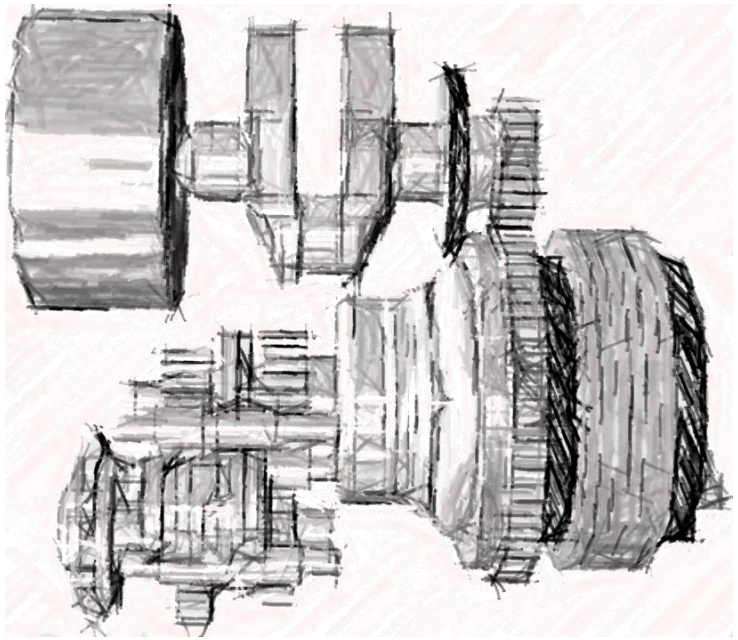
- Consequent reduction of components by highly integrate the EM into the transmission
- 5 powershifted ICE gears (G1-G5)
- G2, G3, G4 parallel hybrid gears
- ICVT mode for ICE launch
- Pure e-drive in 0 emission zone
- Simple actuation system
- No friction clutches
- Better performance with smaller ICE
- Best weight/performance ratio
- Additional functional features

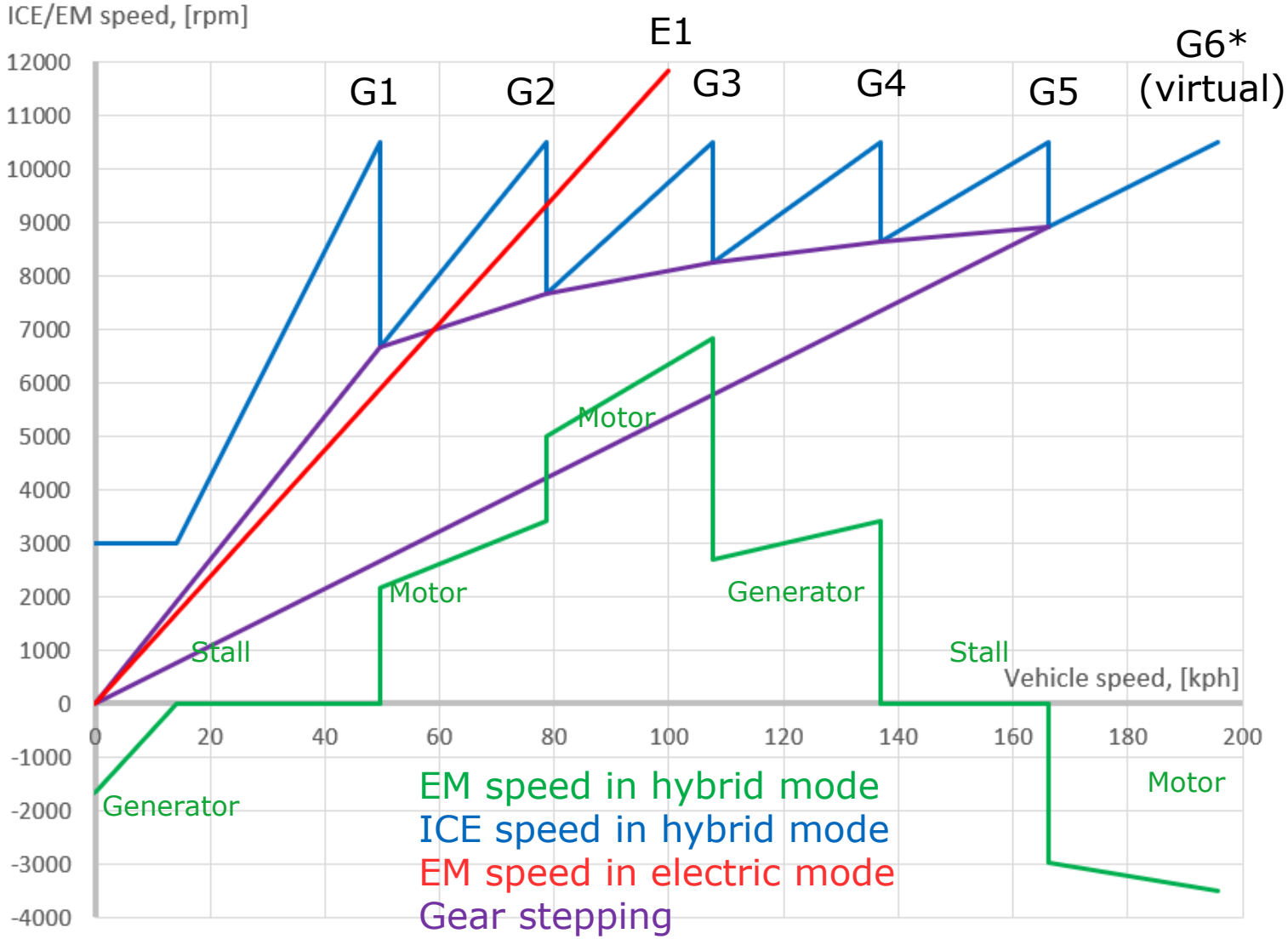
Light DHT Hybrid Powertrain
Overview



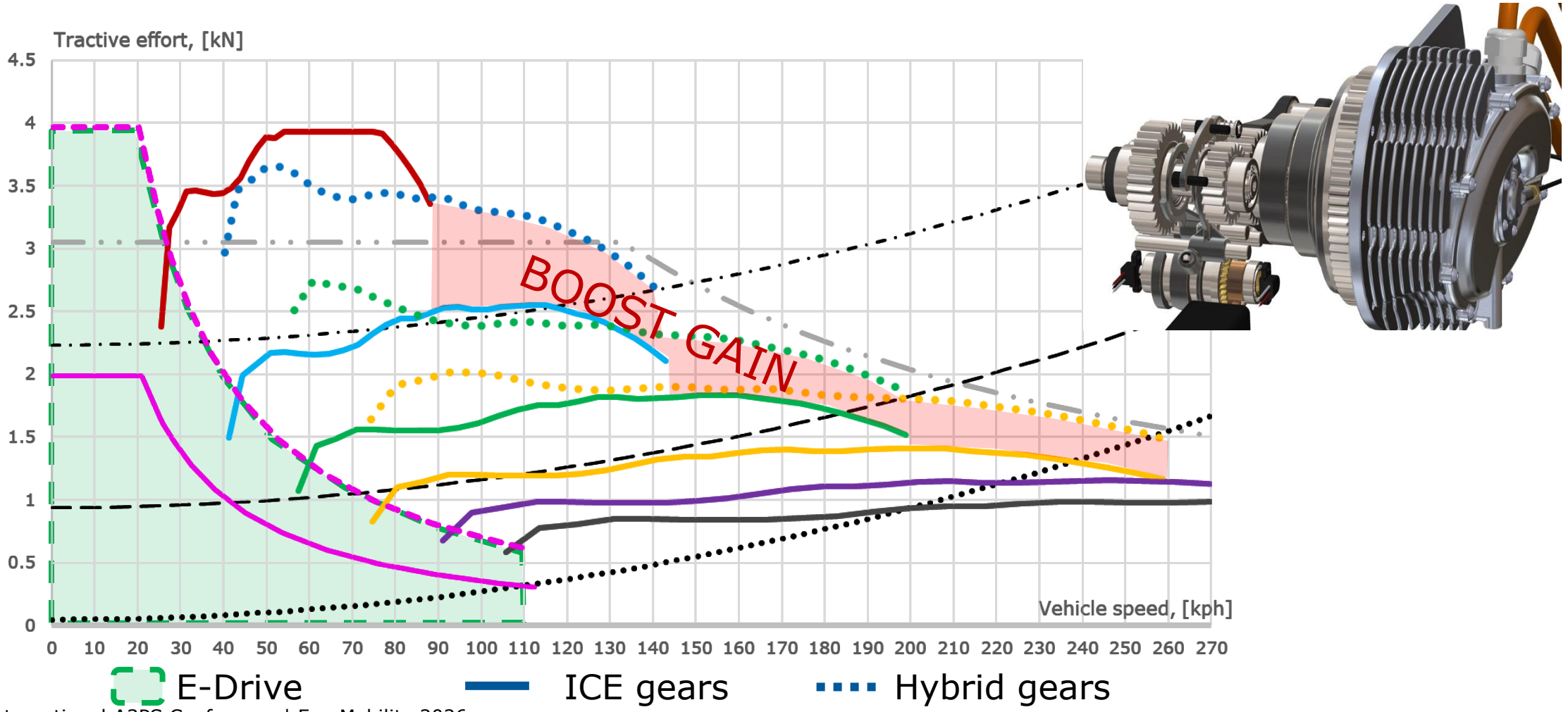
- Compact architecture suitable for 1-cylinder applications
- Single electric motor for electric and hybrid modes, ICE start and battery charging
- 5 dog clutches, operated with a single shift drum system
- 5 ICE gears, with torque-filled seamless shifts
- Parallel hybrid G2,G3 G4 gears (boost & regen braking)
- G1 and G5 gears with stalled EM rotor
- 2 EVT modes enable smooth drive-away and additional virtual gears
- Electric mode, with torque-interrupted shift to ICE/hybrid gears
- ICE restart at standstill and during electric driving

Light DHT Hybrid Powertrain
Fence diagram and rotational speeds



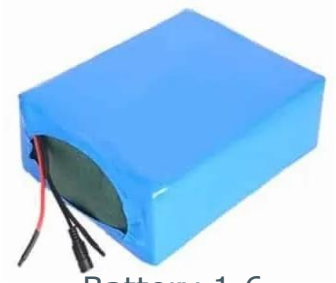


Light DHT Hybrid Powertrain
Highly Integrated DHT – Lightweight Electrification



Light DHT Hybrid Powertrain
Weight gain reduction

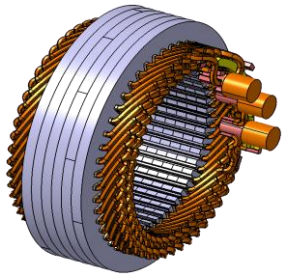
ADDED HYBRID COMPONENTS | +26.0 kg



Battery 1.6 kWh
+17.0 kg



Power electronics
+2.0 kg



E-machine
+7.0 kg

REMOVED / DOWNSIZED COMPONENTS | −9.0 kg



Clutch
−3.0 kg



Starter system
−1.5 kg



Generator
−1.5 kg



ICE downsizing
−3.0 kg

SYSTEM MASS BALANCE

+26.0 kg
added hybrid hardware

−9.0 kg
removed / downsized hardware

NET VEHICLE IMPACT

+17 kg

Performance benefit must be assessed at vehicle level.

Conclusions & Outlook

ARCHITECTURE

5 + 2 + 1

5 ICE gears , 2 EVT modes, 1 EV mode

HYBRID CAPABILITY

3 gears

Boost and recuperation in G2–G4

ELECTRICAL SYSTEM

48–72 V

Single e-machine for drive, start and charge

MASS IMPACT

+17 kg

Including 1,6 kWh battery;

MOTIVATION | 2-WHEELER ELECTRIFICATION

Legislation: City ICE ban, NVH restrictions

Market Entry: Bottom-up – Electrification is entering the 2-Wheeler sector from small to big applications

Market Drivers: Fun to ride & excellent handling due to minimized battery mass/size with maximum overall efficiency

OPPORTUNITIES | BUSINESS IMPACT

Performance differentiation: Torque fill, boost and electric launch expand ride experience

Package leverage: One e-machine covers e-drive, ICE start and charging

Market positioning: Low-voltage hybrid targets performance bikes with limited battery mass



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